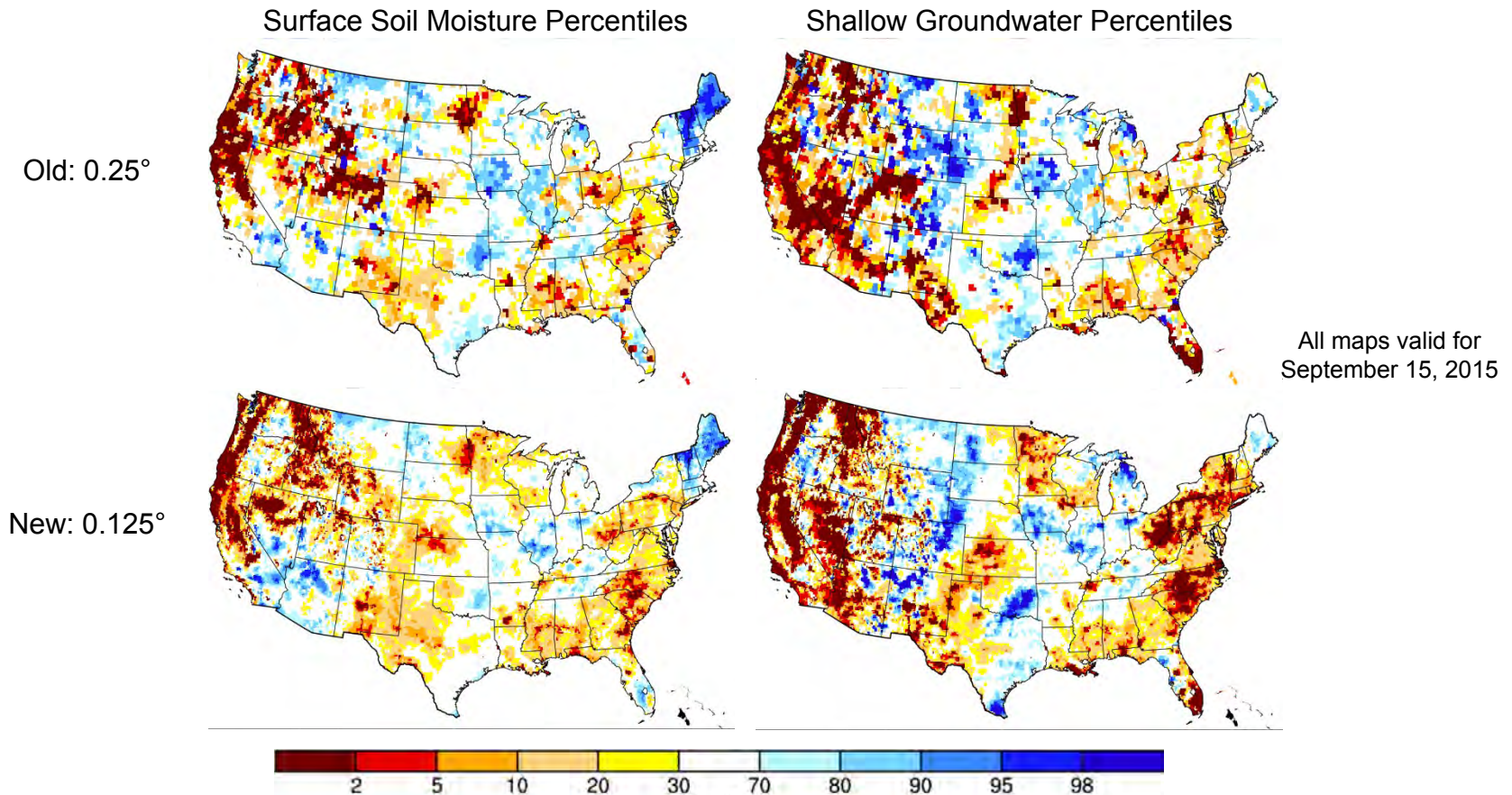




High Resolution GRACE-based Drought/Wetness Maps

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New, higher resolution, soil moisture and groundwater drought/wetness indicator maps enable improved drought and flood risk monitoring. These products integrate data from NASA's Gravity Recovery and Climate Experiment (GRACE) mission with other observations within a sophisticated land surface model in order to characterize wetness conditions. New maps are distributed weekly from <http://www.drought.unl.edu/MonitoringTools.aspx>.



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References:

Houborg, R., M. Rodell, B. Li, R. Reichle, and B. Zaitchik, 2012: Drought indicators based on model assimilated GRACE terrestrial water storage observations, *Water Resources Research*, 48, W07525, doi:10.1029/2011WR011291.

Data Sources: The new drought indicator products and U.S. Drought Monitor are available from <http://www.drought.unl.edu/MonitoringTools.aspx>. Gravity Recovery and Climate Experiment (GRACE) terrestrial water storage data are available from <http://grace.jpl.nasa.gov>.

Technical Description of Figure:

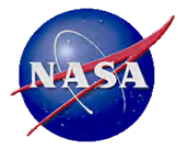
The figure shows drought/wetness indicator maps for surface soil moisture (left column) and groundwater (right column) for September 15, 2015, based on the integration of GRACE terrestrial water storage observations and other data within a numerical land surface model. The previous standard 0.25° resolution maps (top row) are compared with the new standard 0.125° resolution maps (bottom row). All maps were generated by integrating GRACE terrestrial water storage data, meteorological data, and land and vegetation properties within a numerical model of land surface water and energy processes. The improved definition of spatial patterns of wetness is clear in the new maps.

Scientific significance:

Drought costs the U.S. economy upwards of \$8 billion per year. Drought may be defined as a deficiency, relative to the long term average, of water stored on and in the land, including surface waters, soil moisture, and groundwater. On the opposite end of the spectrum, flooding occurs when these natural storage compartments are overwhelmed by rainfall or snowmelt, and the ability to predict floods depends on knowledge of precursor wetness conditions. Soil moisture and groundwater are difficult to measure over large scales using conventional, ground-based techniques. Thanks to satellite observations from NASA's GRACE mission, such data are now becoming available. However, GRACE's spatial and temporal resolutions are low, there is a data latency of 2-3 months, and GRACE does not differentiate one form of land water storage from another. By synthesizing GRACE with other observations within a sophisticated numerical model of land surface water and energy processes, we are able to generate weekly maps of wetness conditions in the soil and shallow aquifers, with the resolution and timeliness necessary for operational drought monitoring. The maps are distributed from <http://www.drought.unl.edu/MonitoringTools.aspx> and used as an input to the U.S. Drought Monitor, which is the nation's premier decision support tool for drought assessment. Recently, we updated the spatial resolution of our GRACE data assimilating model simulations from 0.25° to 0.125° , resulting in improved drought delineation and flood risk assessment.

Relevance for future science and relationship to Decadal Survey:

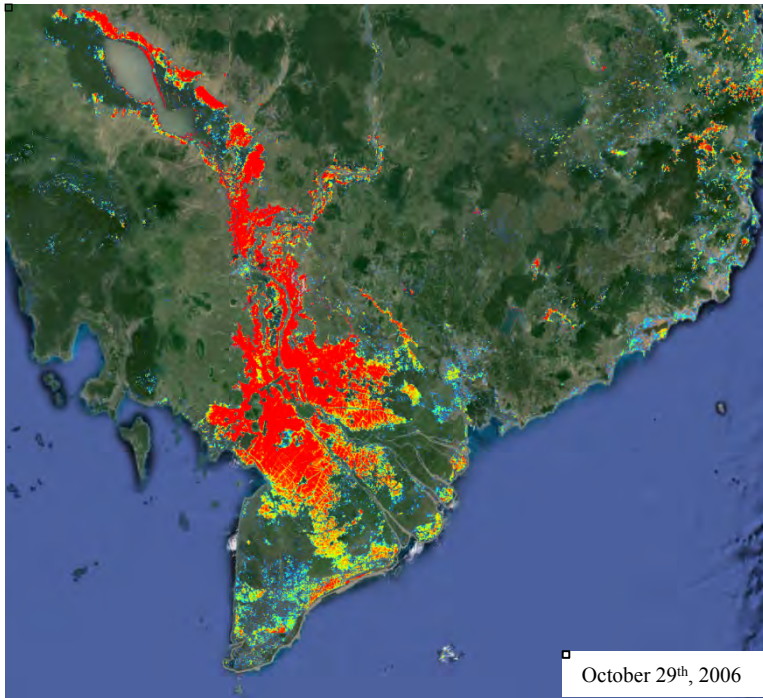
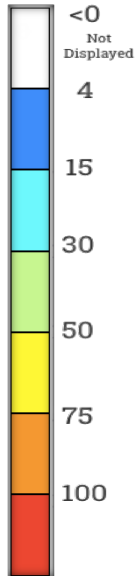
GRACE has survived well past its 5-year design lifetime, and NASA is preparing the GRACE Follow-On mission for launch in August, 2017. The National Research Council's 2007 Decadal Survey in Earth Sciences recommended a more advanced version of GRACE as a Tier 3 mission. Future gravimetry mission concepts are currently being studied.



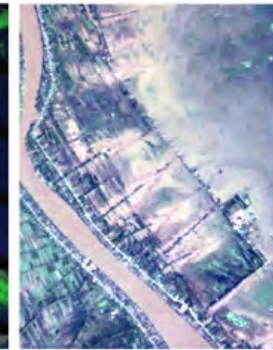
Operational Near Real-Time Flood Inundation Product for the Lower Mekong River Basin

John D. Bolten, Hydrological Sciences, NASA GSFC

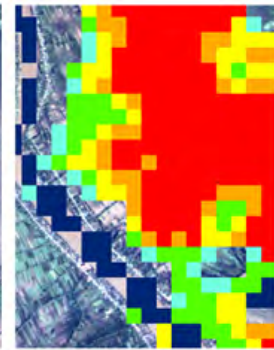
% NDVI
Decrease



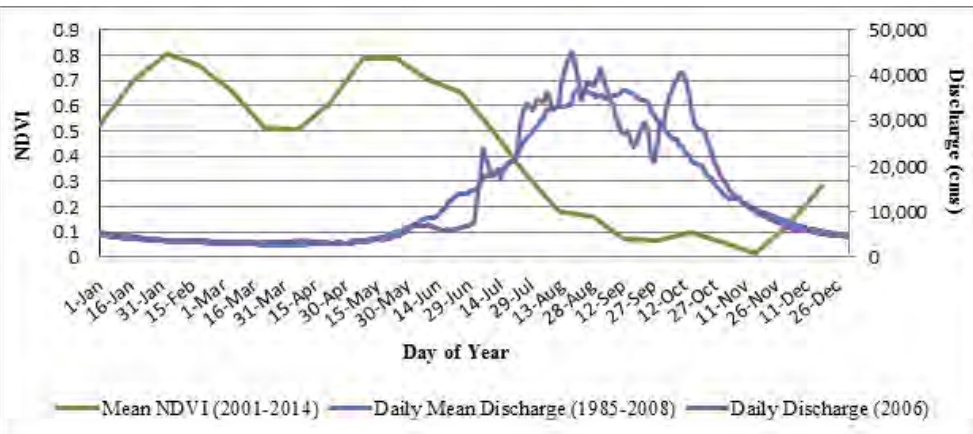
Landsat 7 (RGB 742)
November 1, 2013



ISERV (true color)
November 1, 2013



% Decrease NDVI
0 15 30 45 60 75
Permanent Water



Near real-time flood extent maps are automatically generated by comparing the latest MODIS products (3 hour latency) to a dry season baseline NDVI calculated for Southeast Asia. Images are processed and publicly served on the Southeast Asia Flood Dashboard via the Open Science Data Cloud. Ancillary tools to estimate socioeconomic impacts of flooding are currently in development.



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References:

Doyle, C., Gao, M., Spruce, J., Bolten, J. D., & Weber, S. (2014, December). Utilizing NASA Earth Observations to Enhance Flood Impact Products and Mitigation in the Lower Mekong Water Basin. In *AGU Fall Meeting Abstracts* (Vol. 1, p. 02P).

Doyle, C., J. Bolten, J. Spruce, "Flood Inundation Mapping in the Lower Mekong River Basin Using Multi-temporal MODIS Observations," *Journal of Applied Remote Sensing*. (in review)

Ahamed, A., C. Doyle, J. Bolten, "Assessing flood disaster impacts in Southeast Asia," *Nat. Hazards Earth Sys Sci. (In Prep)*

Data Sources:

Near Real-Time Flood Product: MODIS Surface Reflectance (MOD09, MYD09) obtained from LANCE and processed on Open Science Data Cloud.

Dry Season Baseline NDVI: temporally processed 32-day NDVI for January 2003 – 2011.

Discharge Time Series: Discharge data obtained from Mekong River Commission.

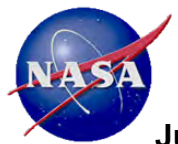
Technical Description of Figures:

Figure 1 (top left): Depicts modeled flood extent in Southeast Asia from MODIS 8 day composite for 10/29/2006. SRTM digital elevation data at 90 meter resolution is used to mask floodplains and set the maximum possible flood extent.

Figure 2 (top right): Comparing the flood inundation product for 11/1/2013 (right, overlain on ISERV imagery) with ISERV natural color imagery (middle), and Landsat 7 ETM+ false color (RGB 7,4,2) imagery from 11/1/2013 (left) demonstrates reasonable agreement between modeled flood extent and visual inundated area extent.

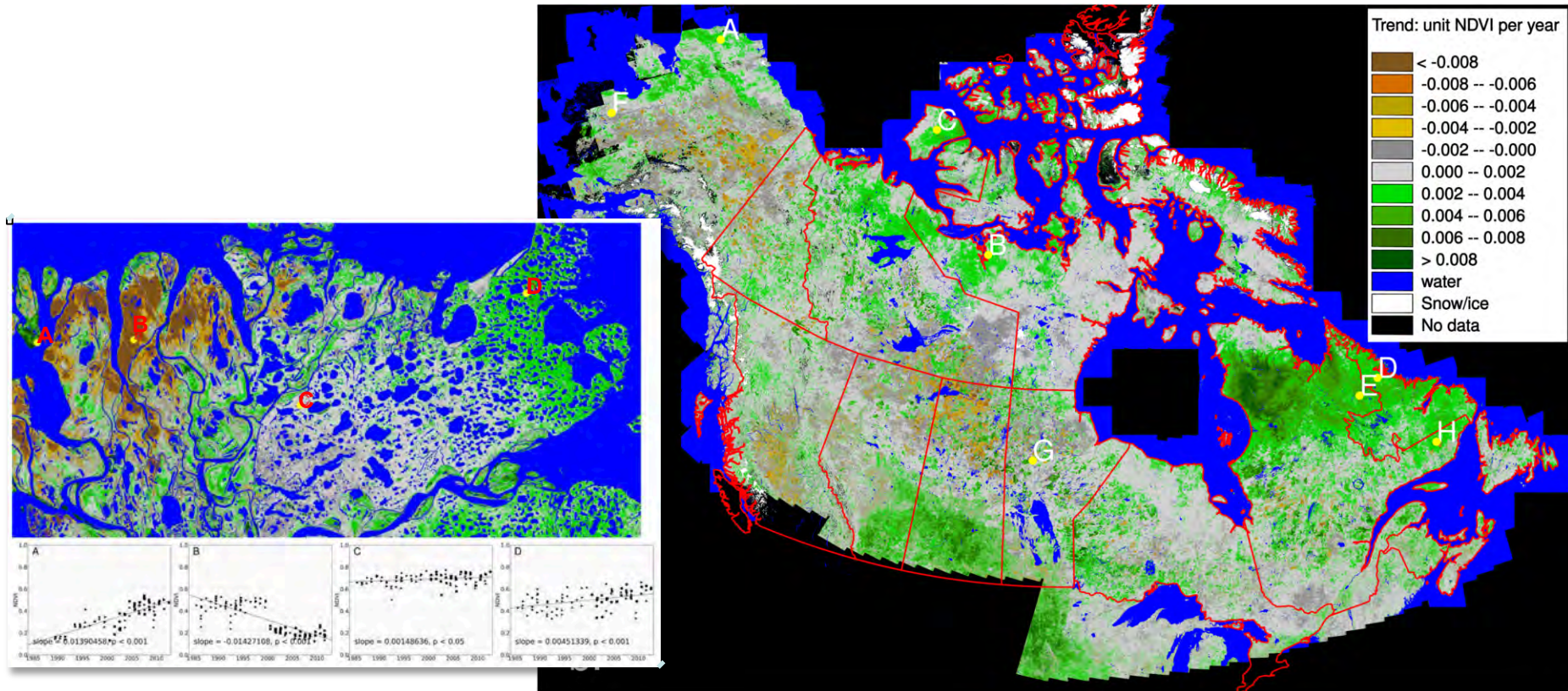
Figure 3 (bottom left): Time series of Terra MODIS-derived NDVI from a rice paddy (green line), mean daily river discharge between 1985 – 2000 for the Mekong River at Kratie, Cambodia (blue line), and 2006 daily discharge (purple line). The effect of seasonal flooding is evident from the dynamic range of NDVI and river discharge. The year 2006 saw multiple tropical storms that caused surges in discharge and extensive flooding, but was otherwise a fairly typical flood year.

Scientific significance, societal relevance, and relationships to future missions: Monitoring flood extent and severity in near real time benefits humanitarian and relief efforts seeking to respond quickly and effectively to monsoon flood disasters, which caused widespread damage in 2006 and 2011. Coupling flood extent and severity with socioeconomic GIS datasets (in development) like population, roads, hospitals, and schools allows for relief agencies to obtain timely estimates of critical supplies, viable travel pathways, affected infrastructure, as well as better geographically focused response efforts. Monitoring flooding in the Lower Mekong also serves to enhance the food security of the region, which depends heavily on seasonal flooding for the cultivation of rice patties and other crops. A similar methodology could be extended to other optical sensors like VIIRS, Landsat, Sentinel-1, and those aboard future missions. The methodology could also be calibrated for other areas of the world that have distinct monsoon flood pulse seasonality. Further research considering flood extent with landcover and crop areas (particularly rice patties) could aid in future infrastructure development as well as crop yield optimization. Southeast Asia is a complex hydrodynamic regime, and real time flood monitoring is essential in the face of climate change, growing population, and with the addition of multiple large scale hydropower dams commissioned to be built in the near future.



Landsat Analysis Zooms In On High Latitude Vegetation Greening

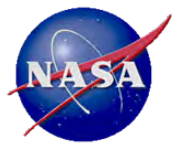
Junchang Ju, Biospheric Sciences, NASA GSFC/USRA, Jeffrey Masek, Biospheric Sciences, NASA GSFC)



Previous studies have indicated widespread circum-Arctic “greening” in response to climate warming, but relied on coarse-resolution AVHRR data sets. 87,000 Landsat images from 1984-2012 were analyzed to measure per-pixel NDVI trends across Canada and Alaska at 30m resolution for the first time.

Results confirm greening found in earlier AVHRR-based studies but with significant regional differences:

- More pronounced NDVI increases in eastern Canada (Quebec)
- Smaller NDVI increases in Alaska
- Most NDVI decreases tied to areas of known disturbance (fire, insect)



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References:

Ju, J., and Masek, J.G., The vegetation greenness trend in Canada and US Alaska from Landsat data, submitted to Remote Sensing of Environment, September 2015

Data Sources: NASA/USGS Landsat-5 and Landsat-7 data; comparisons with GIMMS 3g AVHRR data set.

Technical Description of Figures:

Graphic 1 (right): Mid-summer Landsat-5 and Landsat-7 surface reflectance images from 1984-2012 were downloaded from USGS, screened for clouds and snow, and then converted to Normalized Difference Vegetation Index (NDVI). For each 30m pixel, the linear temporal trend and statistical significance was calculated. The map shows the magnitude of the trend, either NDVI increasing in time (green) or decreasing in time (brown/yellow). Areas with no trend or where insufficient clear pixels could be obtained are grey and black, respectively.

Graphic 2 (inset, left): Top: zoom-in of NDVI trend map for the Mackenzie Delta region, Canada, showing the spatial detail and variability visible in the Landsat-based analysis. Bottom: example NDVI time series from four locations within the Mackenzie Delta. The y-axes are NDVI, and the x-axes are time (1984-2012).

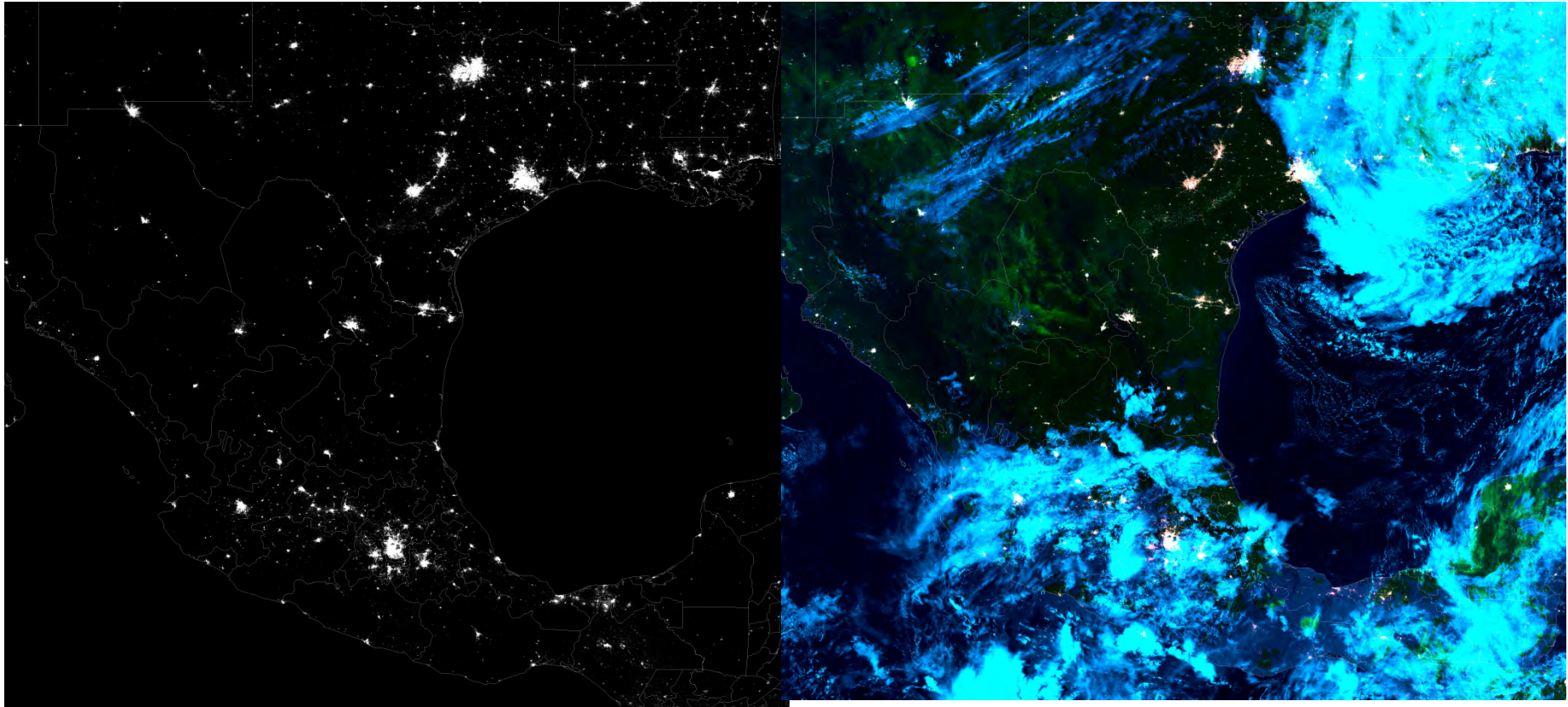
Scientific significance, societal relevance, and relationships to future missions:

Climate change is expected to result in profound changes to global ecosystems over the next several centuries. Some areas currently limited by cold and short growing seasons may experience increased plant cover and/or replacement of cold-tolerant vegetation communities. In other parts of the globe, vegetation stress due to increased aridity and/or increased summer temperatures may lead to widespread plant mortality. High-latitude regions are warming more rapidly than any other part of the globe. Previous ground- and satellite-based studies have indicated that circum-Arctic regions are “greening”, ie. experiencing increased leaf-area and biomass. This study both confirms that trend for northern North America, and also provides a much higher-resolution view of the phenomenon, allowing analysis of local differences in vegetation response.



Hurricane Patricia Disaster Response

Miguel Román & Virginia Kalb (Terrestrial Information Systems, NASA GSFC),
Zhuosen Wang (ORAU),
Andrew Molthan (NASA/MSFC) & Steven Miller (CIRA)



□ Hurricane Patricia was the most intense tropical cyclone ever recorded in the Western Hemisphere. In support of NASA's Tier 1 disaster response activities, Suomi-NPP VIIRS nighttime environmental products were provided in near real time, resulting in rapid acquisition of satellite imagery useful to emergency responders. A new suite of science-quality products, including baseline nighttime lights, as well as cloud-, aerosol-, and lunar-BRDF corrected scenes, were used to help in the immediate detection of outages and to monitor recovery.



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References:

- Molthan, Andrew, and Gary Jedlovec. "Satellite observations monitor outages from Superstorm Sandy." *Eos, Transactions American Geophysical Union* 94.5 (2013): 53-54.
- Román, Miguel, and Eleanor Stokes. "Holidays in lights: Tracking cultural patterns in demand for energy services." *Earth's Future* (2015) doi:10.1002/2014EF000285.

Data Sources: The latest science reprocessing (Collection V1.1) of the Suomi-NPP Visible Infrared Imaging Radiometer Suite (VIIRS) from the VIIRS Land Science Investigator-led Processing System (SIPS) was used in this assessment. These data sets employ the best available VIIRS instrument calibration and characterization results, as well as the latest available algorithm changes applied to the beginning of the VIIRS science mode operation (19 January 2014). All VIIRS data sets, quality assessment reports, and processing tools are publicly available (<http://viirsland.gsfc.nasa.gov/>).

Technical Description of Figure: (Left:) Pre-event nighttime composite imagery from the NASA/NOAA [Suomi National Polar-orbiting Partnership \(Suomi-NPP\)](#) Visible Infrared Imaging Radiometer Suite (VIIRS) day-night band used as a baseline to identify possible power outage areas. **(Right:)** False color composite of pre-event baseline and post-event imagery (27 October 2015). White shades indicate settlements where lights remained stable in both the pre- and post-event imagery, while red areas suggest variations in lighting in the post-event image. Large areas of light-cyan shading correspond to cloud cover that was present only in the post-event image. Green areas denote moon-lit clouds and natural surfaces. Analysis of light-varying areas is limited to cloud-free areas in this compositing technique. Images were created by [NASA's Suomi-NPP VIIRS Land Science-Investigator Led Processing System \(SIPS\)](#) with contributions from [NASA's Short-term Prediction Research and Transition \(SPoRT\) Center](#) and the [Cooperative Institute for Research in the Atmosphere \(CIRA\)](#) at [Colorado State University \(CSU\)](#).

Scientific significance, societal relevance, and relationships to future missions: Low-light visible measurements, capable of detecting individual lights from cities and other terrestrial emission sources, are providing us with new information on urban energy infrastructure. In particular, these products are helping us characterize the drivers that influence energy access — i.e., when and whether communities have access to energy services, and how intermittent that access is (Román and Stokes, 2015). From these new global metrics, other factors associated with urban resilience and vulnerability (e.g., degree of risk and time of recovery) can be estimated. Furthermore, as urban areas continue to grow, VIIRS can help us predict how cities are developing, densifying, and changing form; allowing us to track new and emerging communities in disaster-prone areas.